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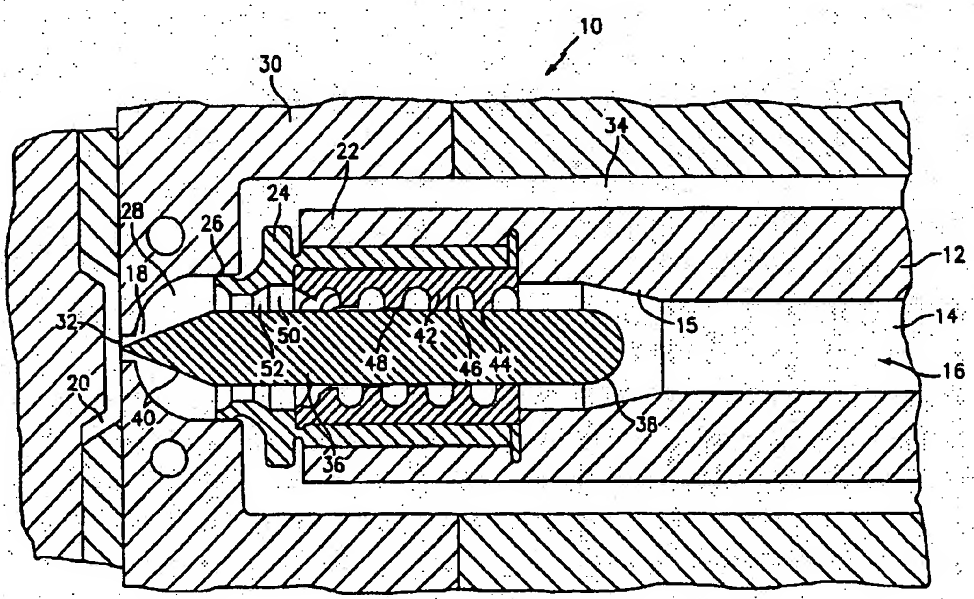
(54) Title: IMPROVED MIXER APPARATUS AND METHOD FOR INJECTION MOLDING MACHINES



(57) Abstract: At least one flow channel (14) is provided in an injection molding machine housing (12) for resin flow, said flow channel having an inlet area (16) for receiving resin and an outlet area (18) for transferring resin to a mold cavity (20) or further downstream. An elongated shaft (36) or valve gate (74) extends in the flow channel (14). At least one spiral groove (46) is provided in the flow channel facing the shaft (36) that decreases in depth towards the outlet area, thereby mixing the molten resin.

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IMPROVED MIXER APPARATUS AND METHOD FOR INJECTION MOLDING MACHINES

TECHNICAL FIELD

Hot runner injection nozzles having torpedoes or valve stems in the melt stream typically create weld line blemishes in the finished part caused by the melt stream being divided by these obstructions and having to reform downstream thereof. The present invention provides an improved injection nozzle and method which includes an improved flow channel geometry to eliminate or significantly minimize these weld lines, while at the same time permitting faster color change performance.

BACKGROUND OF THE INVENTION

When plastic melt flows through a hot runner system en route to a mold cavity, it sometimes must separate from a single solid cylindrical flow mass to pass by obstructions, such as torpedoes, support fins and blades, valve stems, stem guides or support blades. When thus divided, the disturbed melt stream recombines downstream of the obstruction and there forms at least one weld line as the melt streams from the divergent paths come back together. Such a weld line, unless re-mixed homogeneously, thereafter continues to be present in the melt stream and appears as a blemish or line in the molded part formed from the mold cavity. Also when changing color of the melt, considerable amounts of resin are wasted in flushing out the old color that is caught or stuck to these flow obstructions.

U.S. Pat. No. 4,266,723 to Osuna-Diaz and U.S. Pat. No. 4,279,588 to Gellert are examples of heat conducting torpedoes. German Patent DE 32 49 486 to Manner and European Patent 0 638 407 to Krummenacher show valve stems being guided by nozzle tips having fins extending into the melt stream. All of these are examples of melt flow obstructions.

U.S. Pat. No. 5,405,258 to Babin shows a hot runner nozzle having a torpedo which is used to conduct heat absorbed from the

upstream melt along its length to the gate area. The torpedo is positioned within the melt stream and supported by spiral blades that induce a swirling motion to the melt as it flows past them to help provide a stronger product in the gate area. The melt stream divides from a cylindrical stream upstream of the torpedo to an annular stream to pass the torpedo. It is also subdivided in the said annular stream to pass either side of the multiple spiral blades. Downstream of the blades the melt recombines briefly in the annular channel forming weld lines that may appear as lines in the molded part.

U.S. Pat. No.5,849,343 to Gellert et al. shows a valve gated nozzle having a stem guiding nozzle tip that causes the melt to divide from a cylindrical flow to annular flow first to negotiate the valve stem, then to divide again to negotiate the spiral fins supporting the stem at the tip. As in the '258 torpedo version, the melt must subdivide to pass by the spiral blades and recombine again.

The recombination of the flow in all of the foregoing examples typically causes weld lines to appear in the molded part; also color changing becomes lengthy and expensive.

Several attempts at mixing the melt in hot runner nozzles are shown in U.S. Pat. No. 4,965,028 to Maus et al., U.S. Pat. No. 5,513,976 to McGrevy, European Patent 0 546 554 to Gellert, and German Patent DE 32 01 710 to Gellert. A spiral fluted mixer included in an injection molding machine nozzle is shown in Austrian Patent 231696 to Hehl. All of these examples subdivide the melt stream into discrete paths that must recombine downstream of the obstruction and this tends to create flow blemishes in the molded part.

U.S. Pat. No. 5,545,028 to Hume et al. shows a hot runner tip having a semi-torpedo style in which the outer surface of the torpedo includes a flow channel that converts a single cylindrical inlet flow to an annular flow passing by the tip. However, the '028 patent does not show: grooves on the internal side of the tip body, any initial gap or clearance to eliminate hang-ups, a relaxation zone to reduce residual stresses from

flow conversion in a grooved section, or a flow restriction or conformation zone to reduce the thickness variation generated in a grooved zone.

In spiral mandrel dies used in extrusion molding, single or multiple incoming cylindrical melt streams can be converted to a single annular out flowing stream in a continuous process like blown film extrusion molding. U.S. Pat. Nos. 5,783,234 and 5,900,200 to Teng show one application of this in a hot runner valve gated nozzle in which the spiral elements are formed in a comparatively large diameter valve stem and positioned relatively distant from the mold cavity gate. Reference should also be had to the following references: "Analysis for Extrusion Die Design" by B. Proctor, SPE ANTEC, Washington, D.C., pages 211-218 (1971); "The Nuts and Bolts of Blown-Film Design" by C. Rauwendaal, Plastics World, pages 85-87 (1991); and "Extrusion Dies for Plastics and Rubber" by W. Michaeli, Carl Hanser Verlag, Munich, ISBN 3-446-16190-2 (1992).

It is, therefore, a principal object of the present invention to provide a method and apparatus for an improved melt flow mixer located throughout an injection molding machine.

It is a further object of the present invention to provide an improved nozzle and method as aforesaid which eliminates or significantly minimizes weld lines in the finished product.

It is a still further object of the present invention to provide an improved nozzle and method as aforesaid which permits fast color change performance.

Yet another object of the present invention is to provide an improved co-injection nozzle and method which eliminates or significantly reduces weld lines and dips in the molded article, and also to provide an improved method of simultaneous co-injection of two or more materials.

Further objects and advantages of the present invention will appear hereinbelow.

SUMMARY OF THE INVENTION

In accordance with the present invention, the foregoing objects and advantages are readily obtained.

The mixer of the present invention comprises: a flow channel for resin flow having an inlet area for receiving molten resin, an outlet area for transferring molten resin to a mold cavity and an outer surface thereof; an elongated shaft extending in the flow channel, as a movable valve stem or a valve stem guide or a torpedo, adjacent the outlet area; at least one spiral groove formed in the outer surface of the flow channel and facing the shaft that decreases in depth towards the outlet area, with lands adjacent said groove that increase in clearance towards the outlet area, with said groove desirably cut into the outer surface of the flow channel, wherein a helical flow path of resin is provided through the spiral groove and an axial flow path of resin is provided over the lands. The shaft may be a torpedo or a valve stem or a valve stem guide. Preferably, a sleeve is provided in the flow channel adjacent the elongated shaft, wherein the groove is formed in the sleeve. A portion of the lands are generally bonded, press-fit or taper locked or seated to the shaft and the lands increase in clearance with respect to the shaft towards the outlet area.

The injection molding method of the present invention comprises: supplying molten resin to a flow channel having an outer surface thereof in an injection nozzle, which flow channel extends in said nozzle from an inlet area to an outlet area for transferring said molten resin to a mold cavity; providing an elongated shaft in the flow channel adjacent the outlet area; transferring the molten resin to at least one spiral groove, with lands adjacent said groove, said groove formed in the outer surface of the flow channel, and transferring the resin from the groove to the outlet area; decreasing the depth of the groove towards the outlet area and increasing the clearance of the lands towards the outlet area; thereby flowing the resin in a helical flow path through the spiral groove and in an axial flow path over the lands.

Further features of the present invention will appear hereinbelow.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more readily understandable from a consideration of the accompanying illustrative drawings, wherein:

FIG. 1 is a partial sectional view of an exemplicative embodiment of the present invention;

FIG. 1A is a partial sectional view of a further embodiment of the present invention;

FIG. 2 is a sectional view of a further embodiment of the present invention;

FIGS. 3, 4 and 5 are sectional views along lines III--III, IV--IV and V--V, respectively, of FIG. 2

FIGS. 6, 7, 8 and 9 are partial sectional views of further embodiments of the present invention;

FIG. 10 is a partial sectional view of a co-injection exemplicative embodiment of the present invention;

FIGS. 11 and 11A are partial sectional views of further co-injection embodiments of the present invention;

FIGS 12 and 12A are further partial sectional views of further co-injection embodiments of the present invention;

FIGS. 13 and 14 are partial sectional views of further co-injection embodiments of the present invention;

FIG. 15 is a partial sectional view of a further exemplicative embodiment of the present invention installed in a molding machine sprue bar;

FIG. 16 is a partial sectional view of a further embodiment of the present invention;

FIG. 17 is a partial sectional view of a further embodiment of the present invention;

FIG. 18 is an isometric view of the present invention installed in various locations within the flow channel of a hot runner system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In a spiral mandrel die used for extrusion molding the melt stream is first divided into several separate streams using a star shaped, or ring shaped distributor. The streams are then fed into separate spiraling channels cut into the mandrel like a multi-start thread. The depth of the channels constantly decreases and the gap between the mandrel and the inner die wall constantly increases in the direction of flow. This causes a flow stream initially confined within a closed spiral to divide into two streams as it emerges into the widening gap. One stream continues to flow in the spiral channel next to the mandrel wall continuing in a helical direction while a second stream flows over the land of the spiral channel divider and flows in an axial direction. As the spiral channel depth decreases more and more of the resin is added to the axial flow direction. Thus the flow stream gradually transforms from a helical flow direction to an axial flow direction without the creation of weld lines and with the increased mechanical homogeneity and uniformity of melt temperature. This function of operation is not taught by U.S. Pat. No. 4,965,028 which does not teach reducing the channel depth while increasing the wall clearance through the annular flow section of the tip.

When the spiral mandrel die design theory is applied to a hot runner nozzle tip it has been found that with the spiral channels cut into the outer surface of a torpedo insert weld lines are completely eliminated from the surface of the molded part next to the mold core surface, opposite the gate, while blemishes may still occur on the opposed surface formed next to

the mold cavity surface adjacent the gate. This approach is shown in U.S. Pat. Nos. 5,783,234 and 5,900,200. In contrast, when the spiral channels are cut into the outer surface of the nozzle channel opposite the torpedo as in accordance with the present invention, the weld lines are completely eliminated from the surface of the molded part next to the mold cavity surface adjacent the gate while blemishes may still remain on the opposed surface formed next to the mold core surface opposite the gate. Since in most cases this mold cavity formed surface is the outside or shown surface of the molded part, this nozzle configuration represents a much preferred operation.

Analogously, in order to obtain a part having both surfaces free of weld lines, a nozzle tip configuration having spiral channels on both sides of the annular channel section is required as also contemplated in accordance with a preferred embodiment of the present invention.

Other variations on configurations will become apparent from the following detailed descriptions.

Referring to FIG. 1, a torpedo style injection nozzle 10 is shown including a hot runner nozzle housing 12 and a cylindrical melt flow channel 14 in the housing. The flow channel 14 includes an outer surface 15 thereof, inlet area 16 for receiving molten resin and an outlet area 18 for transferring molten resin to mold cavity 20. Threaded into nozzle housing forward end or nozzle tip 22 is nozzle tip retainer 24, typically made of a thermal insulating material such as titanium, that also forms a seal 26 against the bubble area 28 of gate insert 30 such that molten resin flowing through the nozzle fills bubble area 28 before entering mold cavity 20 through gate 32. Seal 26 also prevents molten resin from leaking into insulating space 34 surrounding nozzle housing 12.

Elongated torpedo 36 is provided extending in flow channel 14 adjacent outlet area 18. Torpedo has a curved rear area 38 and a pointed forward area 40 extending to gate 32. Tip retainer 24 traps torpedo 36 in place by engaging sleeve 42 which is welded or brazed at bond area 44 to the torpedo. The torpedo is

desirably made of a thermally conductive material such as beryllium copper or tungsten carbide, while the sleeve can be made of any hard wearing material such as steel or tungsten carbide, possibly manufactured by electrical discharge machining (EDM), powder metal molding, turning, broaching, casting and tapping or any other suitable process.

The outer surface of torpedo 36 is cylindrical. The exposed surface of sleeve 42 includes at least one spiral groove 46. Since the exposed surface of sleeve 42 at least in part forms the outer surface 15 of flow channel 14, the at least one spiral groove 46 is formed in the outer surface of the flow channel and as can be seen in FIG. 1 is cut into the outer surface of the flow channel. In addition, said spiral groove faces torpedo 36.

Lands 48 are provided adjacent said groove. The groove is formed so that it decreases in depth towards outlet area 18 and towards gate 32. Lands 48 are bonded to torpedo 36 at bond area 44 at the upstream end of sleeve 42. The lands 48 present an initial clearance and increase in clearance with respect to torpedo 36 towards outlet area 18 and towards gate 32. The initial clearance is an optional feature and is desirably at least 0.05 mm. This initial clearance is important for color change performance as it enables the flushing of any resin that may hang-up in the dead spots generated between the spiral grooves. Otherwise, the resin will tend to fill part of the small initial clearance and hang-up there for a longer period of time making color change very lengthy. Also, the resin may hang-up there until it degrades and bleeds back into the melt stream. However, with an initial clearance of at least 0.05 mm this abrupt, definite clearance at the end of the contact between the lands and the shaft enables part of the melt stream to flow in the circumference between the grooves to clean the dead spots.

In operation, therefore, the melt flows from the inlet end 16 of flow channel 14 towards outlet end 18 of flow channel 14 through the annular portion of the flow channel. The melt enters one or more of spiral grooves or channels 46 before reaching the outlet end 18. The spiral grooves induce a helical flow path to the melt. As the melt progresses towards the gate 32 progressively

more and more of the melt spills over lands 48 as the lands increase in clearance and as the groove depth decreases so that the helical flow direction is gradually changed to an axial flow direction over the length of sleeve 42. At the end of the spiral groove section, the melt passes to first annular section 50 of flow channel 14 downstream of groove 46 which is comparatively large in diameter, and then passes to a further annular section 52 of channel 14 downstream of first annular section 50 which is reduced in diameter and which is located prior to the end of nozzle tip retainer 24 such that the melt stream is relaxed as it flows through annular section 50. The relaxation section helps to minimize stresses and any flow irregularities and homogenize the melt. Finally, the melt passes through gate 32 to fill the mold cavity 20.

The flowline eliminator tip design can be defined by the following five zones:

A zone of adherence (torpedo version or stem guide) or sliding contacts (valve stem version) between the lands and the shaft may feature a tapered seat that locks the shaft to resist pressure action in the case of a torpedo. This zone provides the support and/or alignment for the torpedo or valve stem guide or guidance of the valve stem.

A zone of a finite initial gap or initial clearance that consists of an abrupt elimination of the contact between the sleeve lands and the shaft. This feature prevents resin hang-ups that may occur when the clearance increase starts from zero. The initial gap allows part of the melt to flow around and clean the dead spots generated between the grooves at the beginning of the clearance increase. The initial clearance value depends on the material processed and the process parameters (flow rate, etc.).

A zone of flow conversion where the melt stream is converted gradually into an annular flow without creating weld lines that will appear in the molded part. In this zone the depth of the grooves decreases gradually and the gap between the shaft and the lands increase gradually.

A relaxation zone that enables the polymer's molecules to relax from the stresses accumulated during the flow conversion in the previous zone. The relaxation zone can be used as well as a run-out for manufacturing tools.

A conformation zone that squeezes the melt through a tight annular section to reduce the thickness variations that may have been generated by the successive spill-overs that occurred during flow conversion. This zone can be an annular section that converges towards the gate if it is required by the application.

The embodiment of FIG. 1A is similar to FIG. 1 wherein torpedo or shaft 36 includes one or more fins 37, as for example 2, 3, or 4 fins, which support the torpedo against nozzle housing 12. Fins 37 include an annular portion 39 which engage the nozzle housing. In the embodiment of FIG. 1A, the torpedo is not welded or brazed as at bond area 44 in FIG. 1, but simply engaged or press-fit at engagement area 45. Thus, a firm engagement is readily provided. As a further alternative, the torpedo can be used as a valve stem guide if it features a guiding hole or channel.

FIG. 2 shows a further embodiment of the present invention of a torpedo style injection nozzle wherein the nozzle tip retainer 24 from FIG. 1 has been eliminated and the spiral channels are formed directly in the nozzle housing or nozzle tip. Thus, FIG. 2 shows torpedo 36', nozzle housing 12' having a forward end or nozzle tip 22', flow channel 14' and gate 32'. In accordance with the embodiment of FIG. 2, spiral groove or channel 46', is formed directly in nozzle tip 22' which is made from a material such as beryllium copper, steel, tungsten carbide or other suitable material. The nozzle tip can if desired be threaded onto a separate nozzle housing. Nozzle tip 22' can be made for example by broaching, casting, tapping, turning, EDM, powder metal molding or any other suitable method. In addition, bubble area 28 has been eliminated by providing insulator 54 adjacent gate 32', which may be made of a suitable polymeric material. This effectively minimizes areas where melt can hang up and

degrade. The conductive torpedo 36' is welded, brazed, press-fit or taper seated to nozzle tip 22' as in FIG. 1. FIGS. 3, 4 and 5 are sectional views along lines III--III, IV--IV and V--V, respectively, showing how the spiral groove geometry varies. Lands 48' are provided adjacent the groove 46'. In a manner after FIG. 1, the spiral groove decreases in depth towards the outlet area 18' and the lands increase in clearance from the torpedo towards the outlet area 18'. First annular section 50' and further annular section 52' are also provided as in FIG. 1.

The embodiment of FIG. 6 shows the nozzle housing 56 with nozzle housing forward end or nozzle tip 58 including a threaded cap 60 that retains sleeve 62 in place. Spiral channels or grooves 64 are formed in sleeve 62. Sleeve 62 also acts as a guide for the movable valve stem 66 which is located in flow channel 68 where the valve stem is contacted by lands 70 at contact areas 72. Downstream of contact areas 72, the contact ceases as the spiral channel or groove depth decreases and the land clearance from the valve stem increases towards valve gate 74. Cap 60 is spaced from gate insert 76 by insulator 78 which may be made from a suitable polymeric material, and if desired this may be backed up with for example a titanium seal insulator 80.

In operation, when valve stem 66 is retracted by suitable motive means (not shown) the melt flows from the annular portion of flow channel 68 into one or more of spiral grooves or channels 64 which induce a helical flow path. As the melt progresses towards valve gate 74 more and more of the melt spills over lands 70 as the lands increase in clearance from the valve stem and as the groove depth decreases so that the helical flow direction is gradually changed to an axial flow direction over the length of sleeve 62. At the end of the spiral groove portion, there is a first annular section 82 of flow channel 68 which is comparatively large in diameter, followed by a further annular section 84 which has a reduced diameter such that the melt stream is relaxed as it flows through the first annular section. The relaxation section help minimize stresses accumulated by the melt during flow conversion and minimize any flow irregularities and homogenize the melt. The relaxation zone also may be used as a tool run-out for certain manufacturing

processes such as tapping, turning, etc. Finally, the melt passes through gate 74 to fill the mold cavity.

FIG. 7 shows a further embodiment of the present invention including dual spiral grooves or channels. In accordance with FIG. 7, injection nozzle 86 includes nozzle tip 88 and flow channel 90 including outer surface 92 thereof. Torpedo 94 is provided in the flow channel. A dual spiral groove or channel 96 is provided by forming an outer groove section 98 in nozzle tip 88 in the outer surface 92 of flow channel 90, and an inner groove section 100 in the adjoining outer surface 102 of torpedo 94 to form a substantially circular groove 96. Lands 104, 105 are provided adjacent the grooves. In accordance with FIG. 7, torpedo 94 is brazed or welded to nozzle tip 88 at upstream land contact areas 106. Naturally, other alignment features can be provided. For example, an alignment means may be provided to align the grooves of the sleeve with grooves of the torpedo, as for example a dowell pin. Thereafter, the depth of spiral channels 96 progressively decreases towards flow channel outlet area 108 and the clearance between lands 104, 105 gradually increases towards outlet area 108. Relaxation zone 110 and diameter reduction zone 112 are provided downstream of the spiral groove as in previous embodiments. The spiral grooves may also have different configurations, angles or opposite orientations, if desired.

In operation, as the melt progresses towards the gate end of the tip progressively more and more of the melt spills over the lands as they increase in clearance and as the groove depth decreases so that the helical flow direction is gradually changed to an axial flow direction. Because melt is spilling over the lands on both sides, there only remains helical flow in the edges of the channel until this too becomes converted to axial flow as the spiral channels blend away. Thus any melt imperfections associated with flow adjacent a smooth wall are eliminated on both sides of the molded part. The torpedo and tip can be the same or dissimilar materials made from for example beryllium copper, steel, tungsten carbide or any other suitable heat conductive abrasion resistant materials. Also possible is a one piece integral piece formed on one material by powder metal

molding, lost core molding or any other suitable manufacturing method.

The embodiment of FIG. 8 is similar to FIG. 7 including a dual spiral groove or channel 96'. However, FIG. 8 includes movable valve stem 114 in a flow channel 90' slidably guided by torpedo insert 116. The torpedo insert is brazed or welded or engaged to nozzle tip 88' at land contact areas 106', as with an alignment feature, such as a dowell pin. This embodiment operates in a manner similar to FIG. 7.

The embodiment of FIG. 9 is similar to FIG. 8 including a spiral groove or channel 96", movable valve stem 114 in flow channel 90" slidably guided by torpedo insert 116'. The torpedo insert is brazed or welded or engaged to nozzle tip 88" at land contact areas 106". However, in the embodiment of FIG. 9, the spiral groove or channel 96" is formed solely in nozzle tip 88" and the torpedo 116", without grooves, acts as a valve stem guide.

The various sealing and insulating details at the bubble and gate end of the nozzle are interchangeable between embodiments. Thus, for example, the nozzle tip retainer 24, polymeric insulator 54 and 78 and titanium seal insulator 80 can be employed in all versions.

Referring to FIG. 10, a valve gate style co-injection nozzle 100 is shown including a hot runner nozzle housing 112 and a cylindrical first melt flow channel 114 in the housing. The flow channel 114 includes an outer surface 115 thereof, inlet area 116 for receiving a first molten resin and a first outlet area 118 for transferring the first molten resin to mold cavity 120. Co-injection nozzle 100 includes a forward end or nozzle tip 124 downstream of nozzle housing 112 and connected thereto.

Elongated torpedo or valve stem 136 is provided extending in flow channel 114 adjacent first outlet area 118. The torpedo may if desired have a flat forward area as shown or a curved rear area and a pointed forward area extending to gate 132. Torpedo or valve stem 136 may desirably be movable to progressively block or open gate 132 or first outlet area 118

and the connection of the first flow channel 114 to the first outlet area 118. Thus, the elongated shaft or torpedo 136 may if desired be a movable valve stem operative to permit and stop resin flow. Naturally, the torpedo or valve stem may have any suitable or convenient configuration.

Nozzle tip 124 trap sleeve 142 in place against nozzle housing 112 with the torpedo or valve stem 136 within sleeve 142 and engaged thereto at contact areas 144, or bonded thereto at contact areas 144. The torpedo or valve stem is desirably made of steel and can also for example be made of a thermally conductive material such as beryllium copper or tungsten carbide, while the sleeve can be made of any hard wearing material such as steel or tungsten carbide, possibly manufactured by electrical discharge machining (EDM), powder metal molding, turning, broaching, casting and tapping or any other suitable process.

The outer surface of torpedo 136 is desirably cylindrical. The exposed surface of sleeve 142 includes at least one first spiral groove 146. Since the exposed surface of sleeve 142 at least in part forms the outer surface 115 of flow channel 114, the at least one spiral groove 146 is formed in the outer surface of the flow channel and as can be seen in FIG. 10 is cut into the outer surface of the flow channel. In addition, said spiral groove faces torpedo 136.

Lands 148 are provided adjacent said groove. The groove is formed so that it decreases in depth towards first outlet area 118 and towards gate 132. Lands 148 desirably contact torpedo 136 at contact area 144 at the upstream end of sleeve 142. The lands 148 present an initial clearance and increase in clearance with respect to torpedo 136 towards first outlet area 118 and towards gate 132.

In addition, nozzle 100 includes a second flow channel 214 which flows circumferentially around first flow channel 114 and includes an inlet area 216 for receiving a second molten resin and a second flow channel outlet area 218 communicating with first outlet area 118 for transferring the second molten resin

through gate 132 to mold cavity 120. Second flow channel 214 includes at least one second spiral groove 246 in the outer surface of nozzle tip 124 forming the inner surface of second flow channel 214 and facing outer nozzle housing 212.

Lands 248 are provided adjacent said second groove. Moreover, similar to the first groove 146, the second groove is formed so that it decreases in depth towards outlet areas 218 and 118 and towards gate 132. Lands 248 may be bonded to or contact outer wall 215 of second flow channel 214 at the upstream end of nozzle tip 124 as in the first flow channel 114.

However, in the embodiment of FIG. 10, lands 248 present an initial clearance with respect to outer wall 215, and an increase in clearance towards outlet areas 218 and 118 and towards gate 132. The initial clearance desirably may have the same dimensions as in the first flow channel and offers the same advantages.

In operation in the second flow channel, therefore, the second melt flows from the inlet end 216 of flow channel 214 towards the outlet end of flow channel 214 through the annular portion of the flow channel. The second melt enters one or more of spiral grooves or channels 246 before reaching the second flow channel outlet area 218 through portals that may desirably be aligned with the start of the helical groove. The alignment may be provided by a dowel pin or locating pin between nozzle housing 112 and outer nozzle housing 212. The spiral grooves induce a helical flow path to the melt. As the melt progresses towards the gate 132 progressively more and more of the melt spills over lands 248 as the lands increase in clearance and as the groove depth decreases so that the helical flow direction is gradually changed to an axial flow direction over the length of grooves 246.

At the end of the spiral groove section, the melt passes to a second flow channel annular section 251 of flow channel 214 downstream of grooves 246, and then passes to second flow channel outlet area 218, outlet area 118, gate 132 and mold cavity 120. Desirably, the first and second melt flows are

sequential, although simultaneous flows or partially simultaneous flows are possible if desired.

The embodiment of FIG. 11 is similar to FIG. 10 except that the second spiral groove 246 is formed in the outer surface 215 of second flow channel 214 opposed to nozzle tip 124. In addition, the second groove 246 decreases in depth towards outlet areas 218 and 118 and with lands 248 increasing in clearance towards outlet areas 218 and 118.

The embodiment of FIG. 11A is similar to the embodiment of FIG. 11 showing grooves 246 in outer nozzle housing 212 formed in a separate insert 213 located by locating pin 122 and held in place by nozzle cap 125.

The embodiment of FIG. 12 includes a third flow channel 260 in injection nozzle 200. Injection nozzle 200 includes nozzle housing 212 and inner nozzle 222. First flow channel 114 for first molten resin flow includes first sleeve 142 held in place by inner nozzle 222 and forming first spiral groove 146. Second inner nozzle 224 forms second spiral groove 246 in second flow channel 214 for second molten resin flow. The third molten resin flows in third flow channel 260 in the outer most portion of nozzle 200 through outer sleeve 243 which is held in place by outer nozzle tip 223 and locating pin 122.

First spiral groove 146 decreases in depth towards third outlet area 318 and outlet area 118′ and first lands 148 increase in clearance towards third outlet area 318 and outlet area 118′. Similarly, second spiral groove 246 decreases in depth towards outlet areas 318 and 118′ and second lands 248 increase in clearance towards outlet areas 318 and 118′. Also, third spiral groove 346 decreases in depth towards outlet areas 318 and 118′ and third lands 348 increase in clearance towards outlet areas 318 and 118'.

In the embodiment of FIG. 12, if desired first sleeve 142 and first spiral groove 146 may be located relatively farther upstream from the second spiral groove than in the embodiments of FIGS. 10 and 11. Also, in the embodiment of FIG. 12, molten

resin flows from first spiral groove 146 directly into first flow channel 114. Also, desirably, the resin flows are sequential.

Thus, the flow paths of the first, second and third resins are through spiral grooves that decrease in depth towards the outlet areas and with lands adjacent the grooves that increase in clearance towards the outlet areas so that a helical flow path of the resins is provided through the respective spiral grooves and an axial flow path of the resins is provided over the respective lands. Moreover, the co-injection nozzle of FIG. 12 with three (3) resins obtains the aforesaid considerable advantages of the present invention, e.g., elimination of weld lines, homogeneous flow and uniform annular flow velocity which leads to uniform layering, elimination of the dip effect and reduction of nozzle shifting.

The embodiment of FIG. 12A is similar to the embodiment of FIG. 12 showing the third spiral groove 346 on the inside surface of insert 244.

The embodiments of FIGS. 13 and 14 both show a co-injection nozzle 200 with three flow channels 114, 214 and 260 for three molten resin flows, as with the embodiment of FIG. 12. However, in the embodiment of FIG. 13, the second spiral groove 246 is formed in the inner surface 217 of second flow channel 214 in the inner nozzle 222, with lands 248 and grooves 246 facing nozzle housing 212. Also, the first spiral groove 146 in first flow channel 114 is formed in first sleeve 142 held in place in the forward end of first flow channel 114 by first retainer 149 which forms an outer surface 115 of the first flow channel 114.

In the embodiment of FIG. 14, the second spiral groove 246 is formed in the outer surface 215 of second flow channel 214 in nozzle housing 212, with lands 248 and grooves 246 facing inner nozzle tip 222.

Referring now to FIG. 15, (where like features use like numerals) another preferred embodiment of the present invention 300 is shown in which the mixer apparatus is installed in a

sprue bar 12a of an injection molding machine. A torpedo style melt mixer 300 is shown including a cylindrical flow channel sprue bar 12a and a melt flow channel 14a in the sprue bar. The flow channel 14a includes an inner surface 15a thereof, inlet area 16a for receiving molten resin and an outlet area 18a for transferring molten resin further downstream in a hot runner channel 52a.

Elongated torpedo 36a is provided extending in flow channel 14a adjacent outlet area 18a. The torpedo 36a has a curved rear area 38a and a pointed forward area 40a. The torpedo is trapped and located in the flow channel 14a by a sleeve 42a which is inserted into the flow channel housing 12a. The torpedo 36a is engaged by the sleeve 42a at bond area 44a, which rigidly affixes the torpedo to the sleeve by welding, brazing or similar retention means.

The outer surface of the torpedo 36a is cylindrical. The exposed surface of the sleeve 42 includes at least one spiral groove 46a. Since the exposed surface of the sleeve 42a at least in part forms the inner surface 15a of flow channel 14a, at least one spiral groove 46a is formed in the inner surface of the flow channel. In addition, said spiral groove faces torpedo 36a.

Lands 48a are provided adjacent the spiral groove 46a. The groove is formed so that it decreases in depth towards the outlet area 18a. Lands 48a are bonded to torpedo 36a at bond area 44a adjacent the inlet area 16a. The lands 48a present an initial clearance and increase in clearance with respect to torpedo 36a towards outlet area 18a. The initial clearance is an optional feature and is preferably at least 0.05mm.

Referring now to FIG. 16, this embodiment is similar to FIG. 15 (so similar numerals are used to point out similar features) wherein the torpedo 36a is a tapered shaft with a helical groove therein. Alternatively, the torpedo 36a could be cylindrical, with the spiral grooves 46a decreasing in depth towards the outlet area 18a. The melt flows into an annular inlet area 16a of the torpedo 36a and then enters at least one spiral groove

46a located on the outer surface of the torpedo 36a. Similar to the embodiment of FIG. 15, the depth of the spiral groove 46a decreases toward the outlet area 18a. Located adjacent groove 46a, are lands 48a which interface with the sleeve 42a, the height of the lands 48a decrease towards the outlet area 18a. The biggest difference between this embodiment and the embodiment shown in FIG. 15 is that the location of the spiral groove 46a is on the outside surface of torpedo 36a, facing the flat cylindrical surface of sleeve 42a. Alternatively, the cylindrical surface of sleeve 42a could be tapered so as to create a gradually changing gap with the lands 48a.

Referring now to FIG. 17, another embodiment of the present invention is shown. This embodiment is similar to the previously discussed embodiments in FIGS. 15 and 16, with the biggest difference being that a second spiral groove 58a is formed in the inside surface of the sleeve 42a, the second spiral groove faces the torpedo 36a, with second lands 60a adjacent the second spiral groove 58a. Lands 48a are located adjacent the second lands 60a, with the gap created between the lands 48a and 60a increasing towards the outlet area 18a. The second spiral groove 58a is located adjacent the spiral groove 48a, thereby creating a contiguous spiral groove for the melt as it travel towards the outlet area 18a.

Referring to FIG. 18, the preferred embodiments 300 of the present invention can be installed in many locations within an injection molding machine and a hot runner system. As the biggest flow imbalances are caused by the splitting of the non-homogenous melt within the hot runner channel 52a, the present invention performs best if installed upstream at each branch in the molding machine. The mixer of the present invention increases the melt homogeneity before a split occurs, thereby reducing the presence of any flow imbalances. Reducing flow imbalances as previously discussed reduces the chances of weld lines in the product as well as ensure equal filling of the mold cavities.

The present invention is highly advantageous. Testing has demonstrated that the present invention eliminates weld lines,

produces a homogeneous melt, and enables fast color changes and a stronger molded part, particularly in the gate area.

Significant features of the present invention include the spiral flow channels with their decreasing depth and increasing land clearance. The initial clearance with a finite length minimizes or eliminates possible hang-ups at the start of clearance. The initial clearance is a significant feature for color change performance as it enables the flushing of any resin that may hang-up in the dead spots generated between the spiral grooves. In case of the absence of initial clearance, the resin fills part of the small clearance and then hangs-up there for a longer time making color change very lengthy. The resin may also hang-up there until it degrades and bleeds back into the melt stream. The present invention eliminates or substantially minimizes flow lines especially if no initial clearance is provided. However, when an abrupt definite clearance is provided at the end of the contact between the lands and the shaft, it is possible to enable part of the melt stream to flow in the circumference between the grooves to clean the dead spots. In addition, a relaxation space is provided downstream of the spiral channels. The present invention is also suitable for use with both pin point torpedo, stem guiding torpedo, and sliding valve stem configurations and is particularly versatile.

It is to be understood that the invention is not limited to the illustrations described and shown herein, which are deemed to be merely illustrative of the best modes of carrying out the invention, and which are susceptible of modification of form, size, arrangement of parts and details of operation. The invention rather is intended to encompass all such modifications which are within its spirit and scope as defined by the claims.

WHAT IS CLAIMED IS:

1. A melt flow mixer for an injection molding machine, which comprises:

a flow channel (14) for resin flow having an inlet area (16) for receiving molten resin, an outlet area (18) for transferring molten resin to a mold cavity (20), said flow channel including an outer surface (15) thereof;

an elongated member (36) extending in the flow channel (14) adjacent the outlet area (18); and

at least one spiral groove (46) formed in the outer surface (15) of the flow channel (14) and facing the elongated member (36) that decreases in depth towards the outlet area (18), with lands (48) adjacent said groove (46) that increase in clearance towards the outlet area (18);

wherein a helical flow path of resin is provided through the spiral groove (46) and an axial flow path of resin is provided over the lands (48).

2. A mixer according to claim 1, wherein said groove (46) is cut into the outer surface (15) of the flow channel.

3. A mixer according to claim 1, including a gate (32) in the outlet area (18) for transferring resin to a mold cavity (20).

4. A mixer according to claim 1, including a sleeve (42) in the flow channel (14) adjacent the elongated member (36), wherein said groove (46) is formed in the sleeve (42).

5. A mixer according to claim 4, wherein a portion of the lands (48) are bonded to the elongated member (36) and wherein the lands (48) increase in clearance with respect to the elongated member (36) towards the outlet area (18).

6. A mixer according to claim 1, wherein said elongated member (36) is a movable valve stem (74) operative to permit and stop resin flow.

7. A mixer according to claim 1, wherein said elongated member (36) is a torpedo or valve stem guide.

8. A mixer according to claim 1, including a first annular section (50) of said flow channel (14) downstream of said spiral groove (46).

9. A mixer according to claim 8, including a further annular section (52) of said flow channel (14) downstream of said first annular section (50) with a reduced diameter.

10. A mixer according to claim 4, including a nozzle tip (58) adjacent the outlet area of the flow channel (68) and a nozzle tip retainer (60) engaging the nozzle tip (58) and holding the sleeve (62) in place.

11. A mixer according to claim 1, including a nozzle tip (22′) adjacent the outlet area (18′) of the flow channel (14′), wherein said spiral groove (46′) is formed in said nozzle tip (22′).

12. A mixer according to claim 1, wherein said helical flow path is gradually changed to an axial flow path.

13. A mixer according to claim 1, wherein said spiral groove (96) is formed in the outer surface (92) of the flow channel (90) and in the outer surface of said elongated member (94).

14. A mixer according to claim 13, wherein said groove (96) is substantially circular.

15. A mixer according to claim 13, including a movable valve stem (114) in the flow channel (90′) which is guided by a torpedo insert (116′), with the spiral groove (96′) formed in the outer surface of the flow channel (90′) and in the outer surface of the torpedo insert (116′).

16.A mixer according to claim 1, including a movable valve stem (114) in the flow channel (90'') which is guided by a torpedo insert (116''), with the spiral groove (96'') formed solely in the outer surface of the flow channel (90'').

17.A mixer according to claim 1, including an initial clearance between the elongated member (36) and the lands (48) of at least 0.05 mm.

18.A mixer according to claim 1, wherein said elongated member (36) includes at least one supporting fin (37).

19.An injection molding method, which comprises:

supplying molten resin to a flow channel (14) having an outer surface (15) thereof, in an injection nozzle, which flow channel (14) extends in said nozzle from an inlet area (16) to an outlet area (18) for transferring said molten resin to a mold cavity (20);

providing an elongated member (36) in said flow channel (14) adjacent said outlet area (18);

transferring said molten resin to at least one spiral groove (46), with lands (48) adjacent said groove (46), said groove (46) formed in the outer surface (15) of said flow channel (14), and transferring said resin from said groove (46) to said outlet area (18); and

decreasing the depth of said groove (46) towards the outlet area (18) and increasing the clearance of said lands (48) towards the outlet area (18);

thereby flowing said resin in a helical flow path through the spiral groove (46) and in an axial flow path over the lands (48).

20.A method according to claim 19, including transferring said

resin from the spiral groove (46) to a gate (32) in the outlet area (18) for transferring resin to a mold cavity (20).

21. A method according to claim 19, including transferring said resin to said groove (64) which faces a movable valve stem (74) operative to permit and stop resin flow.

22. A method according to claim 21, including transferring said resin to said groove (64) which faces a torpedo or valve stem guide (74).

23. A method according to claim 21, including the step of cutting said groove (64) in the outer surface of said flow channel (68).

24. A method according to claim 21, including the step of providing a sleeve (62) in the flow channel (68) adjacent the valve stem (74) and forming said groove (64) in said sleeve (62).

25. A method according to claim 24, including the step of bonding a portion of the lands (48) to the elongated member (38) and increasing the clearance of the lands (48) with respect to the elongated member (38) towards the outlet area (18).

26. A method according to claim 21, including transferring said resin from the spiral groove (46) to a first annular section (50) of said flow channel (14) downstream of said spiral groove (46).

27. A method according to claim 26, including transferring said resin from said first annular section (50) to a further annular section (52) of reduced diameter.

28. A method according to claim 19, including providing a nozzle tip (22′) adjacent the outlet area (18′) of the flow channel (14′), and forming said spiral groove (46′) in the nozzle tip (22′).

29. A method according to claim 19, including gradually changing said flow path from a helical flow path to an axial flow

path.

30.A method according to claim 19, including forming said groove (96) in the outer surface (92) of the flow channel (90) and in the outer surface of said elongated member (94).

31.A method according to claim 30, including forming a substantially circular groove.

32.A method according to claim 30, including guiding a movable valve stem (114) in the flow channel (90′) by a torpedo insert (116′), and forming said groove (96′) in the outer surface of the flow channel (90′) and in the outer surface of the torpedo insert (116′).

33.A method according to claim 19, including guiding a movable valve stem (114) by a torpedo insert(116′′), and forming said groove (96′′) solely in the outer surface of the flow channel (90′′).

34.A method according to claim 19, including the step of providing an initial clearance of at least 0.05 mm between the elongated member (36) and the lands (48).

35.A method according to claim 19, including the step of providing said elongated member (36) with supporting fins (37).

36.A coinjection nozzle, which comprises:

a first flow channel (114) for a first resin flow communicating with a first outlet area (118) for transferring molten first resin, said first flow channel (114) including an outer surface (115) thereof, an elongated shaft (136) extending in the first flow channel adjacent the first outlet area (118), at least one first spiral groove (146) formed in the outer surface (115) of the first flow channel (114) and facing the shaft (136) that decreases in depth towards the first outlet area (118), with lands (148) adjacent said first groove (146) that increase in clearance towards the first outlet area (118), wherein a helical flow path of said first resin

is provided through the first spiral groove (146) and an axial flow path of said first resin is provided over the lands (148); and

at least one second flow channel (214) for a second resin flow communicating with a second outlet area (218) for transferring molten second resin, at least one second spiral groove (246) in the second flow channel (218) that decreases in depth towards the second outlet area (218) with lands (248) adjacent said second groove (246) that increase in clearance towards the second outlet area (218), wherein a helical flow path of said second resin is provided through the second spiral groove (246) and an axial flow path of said second resin is provided over the lands (248).

37.A nozzle according to claim 36, wherein a portion of the lands (148) in the first flow channel (114) contact the shaft (136) and wherein the lands (148) increase in clearance with respect to the shaft (136) towards the first outlet area (118).

38.A nozzle according to claim 36, wherein said shaft (136) is a movable valve stem operative to permit and stop resin flow.

39.A nozzle according to claim 36, including a first annular section (150) of said first flow channel (114) downstream of said first spiral groove (146).

40.A nozzle according to claim 39, including a further annular section (152) of said first flow channel (114) downstream of said first annular section (150), wherein said further annular section (152) has a reduced diameter.

41.A nozzle according to claim 36, wherein said helical flow path in said first and second flow paths (114, 214) is gradually changed to axial flow paths.

42.A nozzle according to claim 36, wherein said second flow channel (214) flows circumferentially around said first flow

(channel (114).

43. A nozzle according to claim 36, including a sleeve (142) in the first flow channel (114) adjacent the elongated shaft (136), wherein said first groove (146) is formed in the sleeve (142).

44. A nozzle according to claim 43, including a nozzle tip (124) adjacent the forward end of the first flow channel holding the sleeve (142) in place.

45. A nozzle according to claim 44, wherein said second groove (246) is formed in the outer surface of said nozzle tip (124).

46. A nozzle according to claim 36, including a second annular section (251) downstream of said second groove (246).

47. A nozzle according to claim 36, wherein the second groove (246) is formed in the outer surface (215) of said second flow channel (214).

48. A nozzle according to claim 36, including at least one third flow channel (260) for a third resin flow communicating with a third outlet area (318) for transferring molten third resin, at least one third spiral groove (346) in the third flow channel (260) that decreases in depth towards the third outlet area (318) with lands (348) adjacent said third groove (346) that increase in clearance towards the third outlet area 318), wherein a helical flow path of said third resin is provided through the third spiral groove (346) and an axial flow path of said third resin is provided over said lands (348).

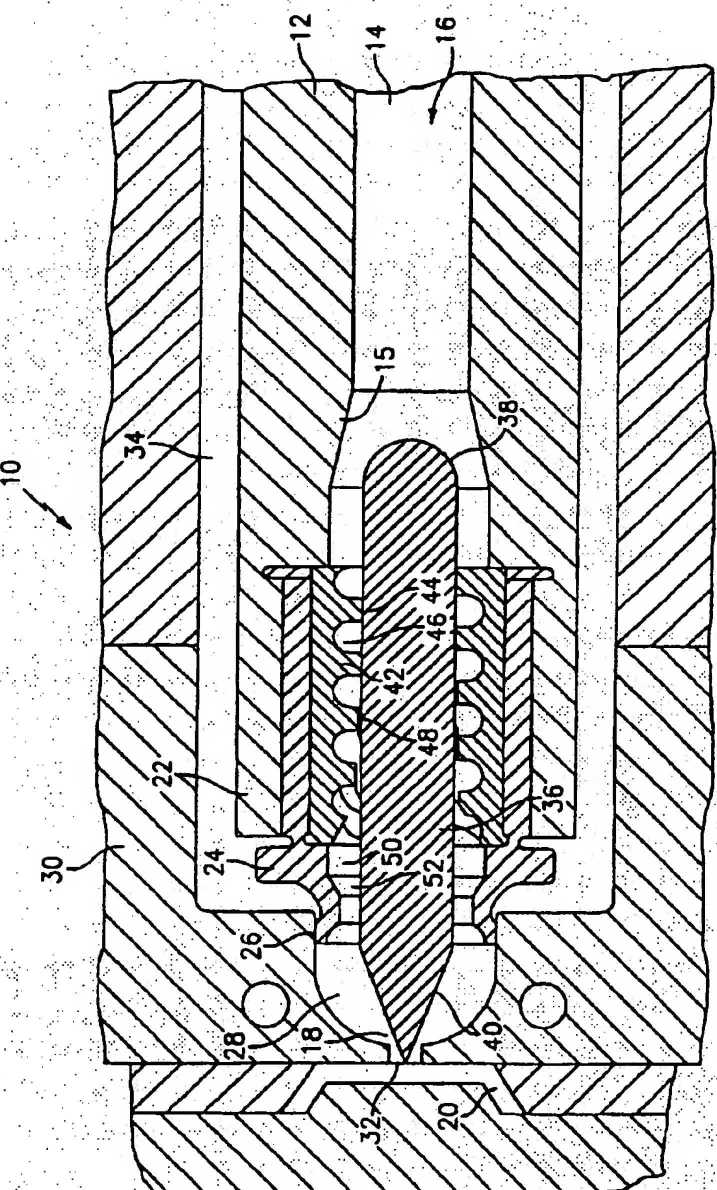
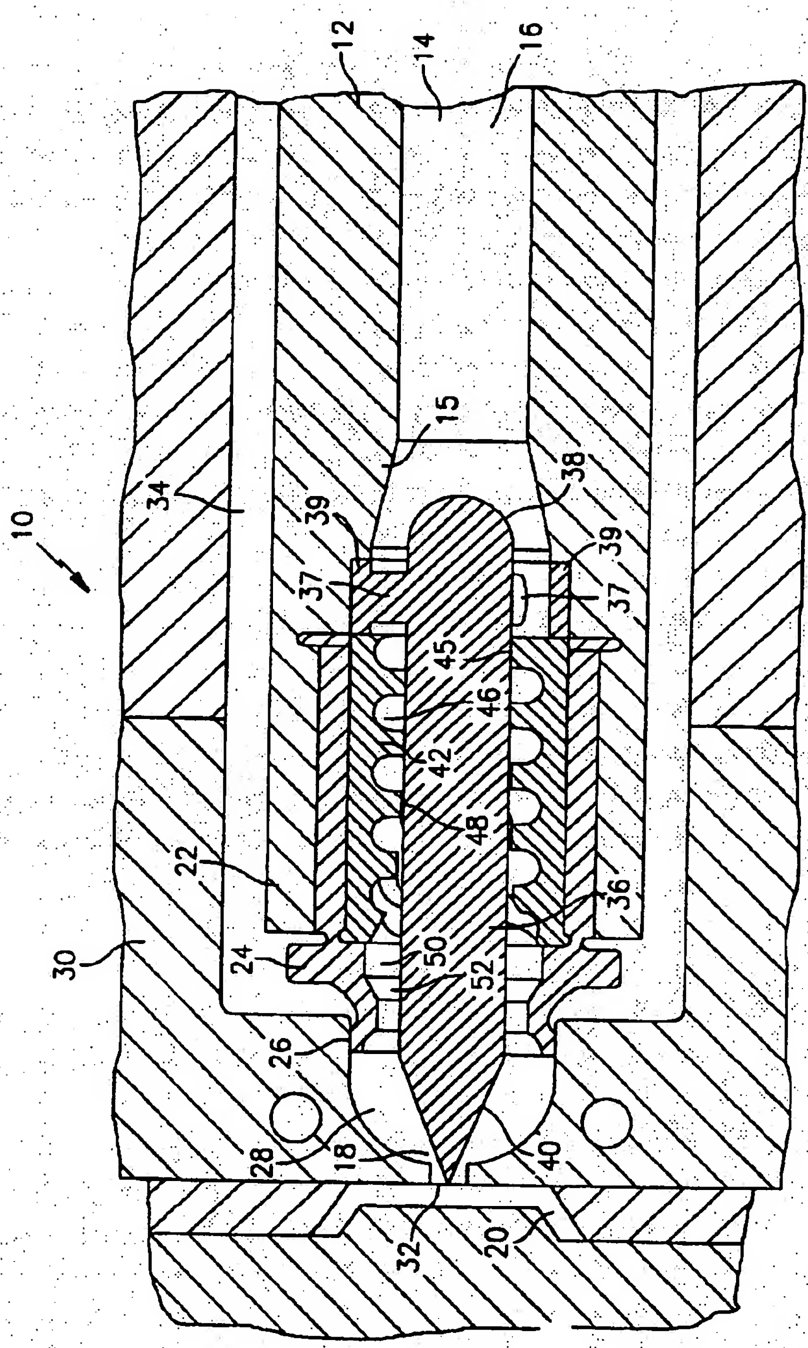


FIG. 1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16
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38
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37
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26
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32
20

FIG. 1A

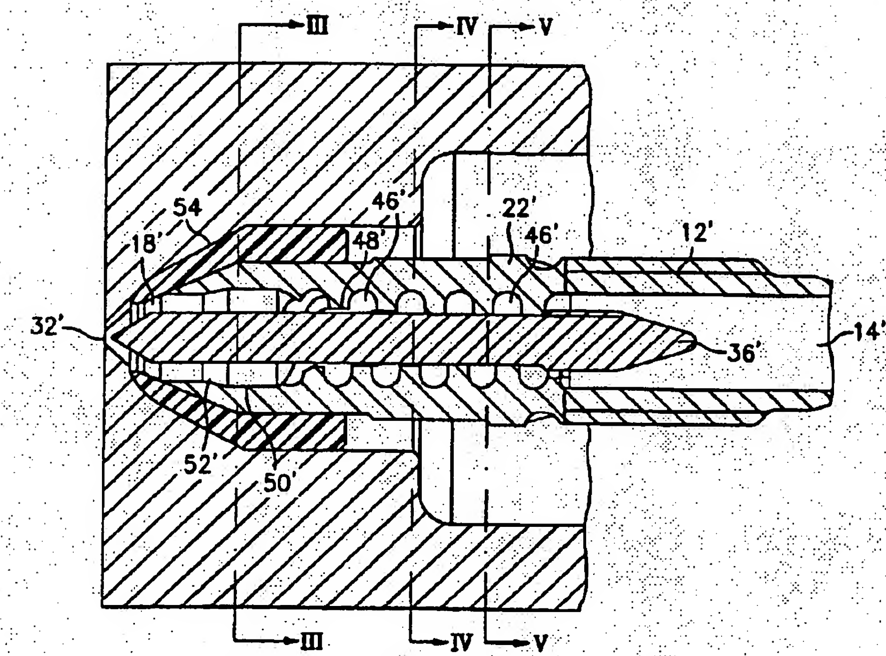
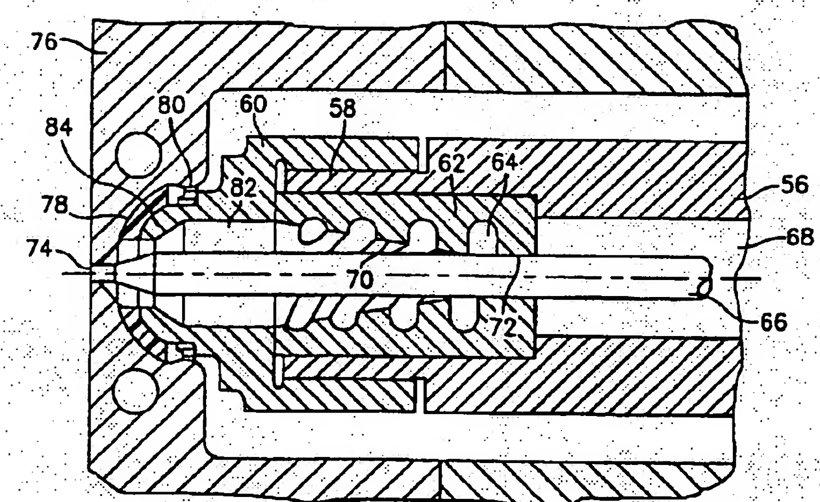

III
IV
V
54
18'
46'
48'
22'
46'
12'
32'
36'
14'
52'
50'
III
IV
V

FIG. 2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60
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84
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56
78
74
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68
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66

FIG. 6

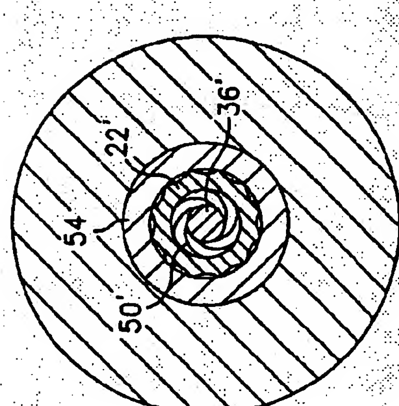


FIG. 3

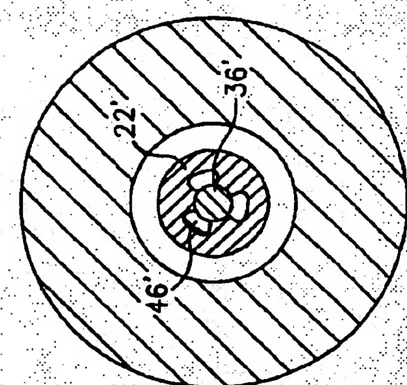


FIG. 4

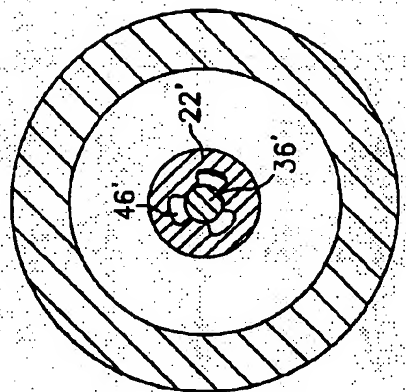


FIG. 5

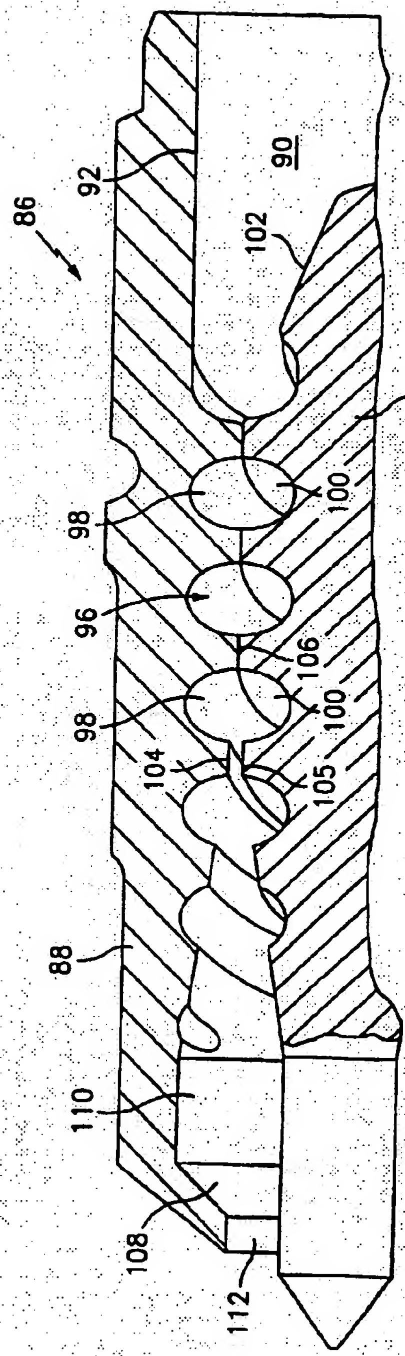


FIG. 7

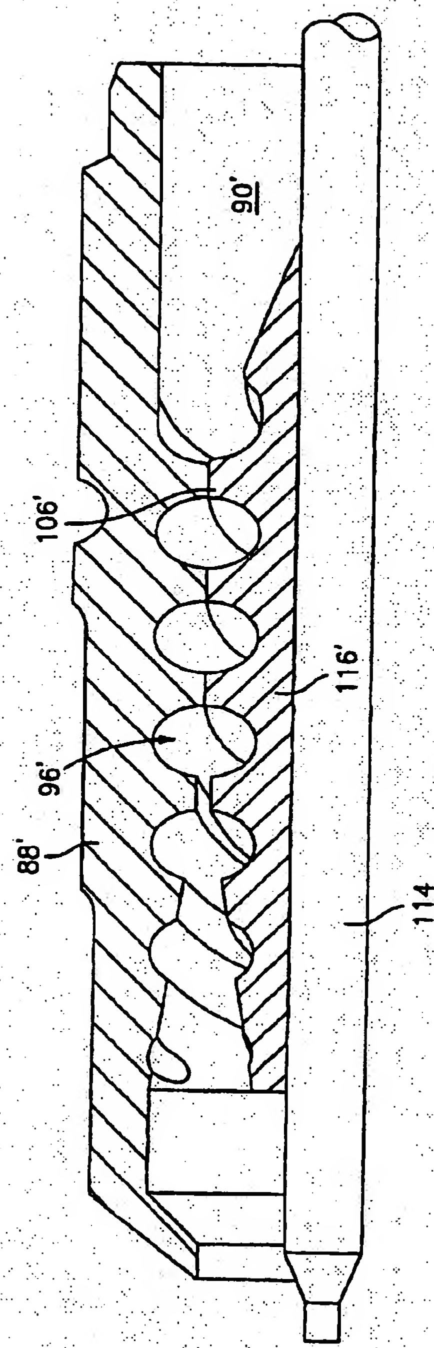


FIG. 8

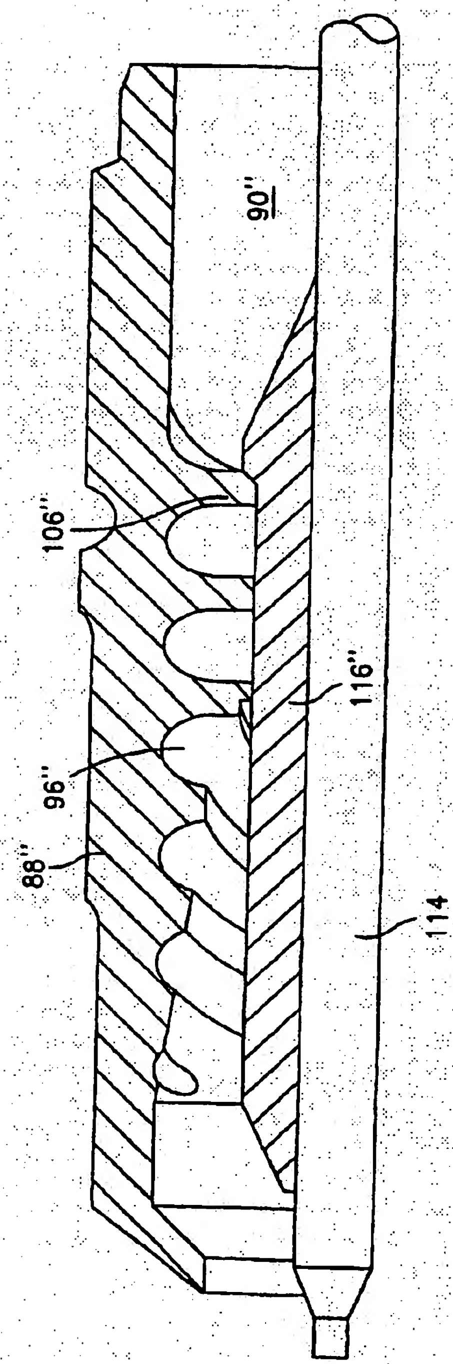


FIG. 9

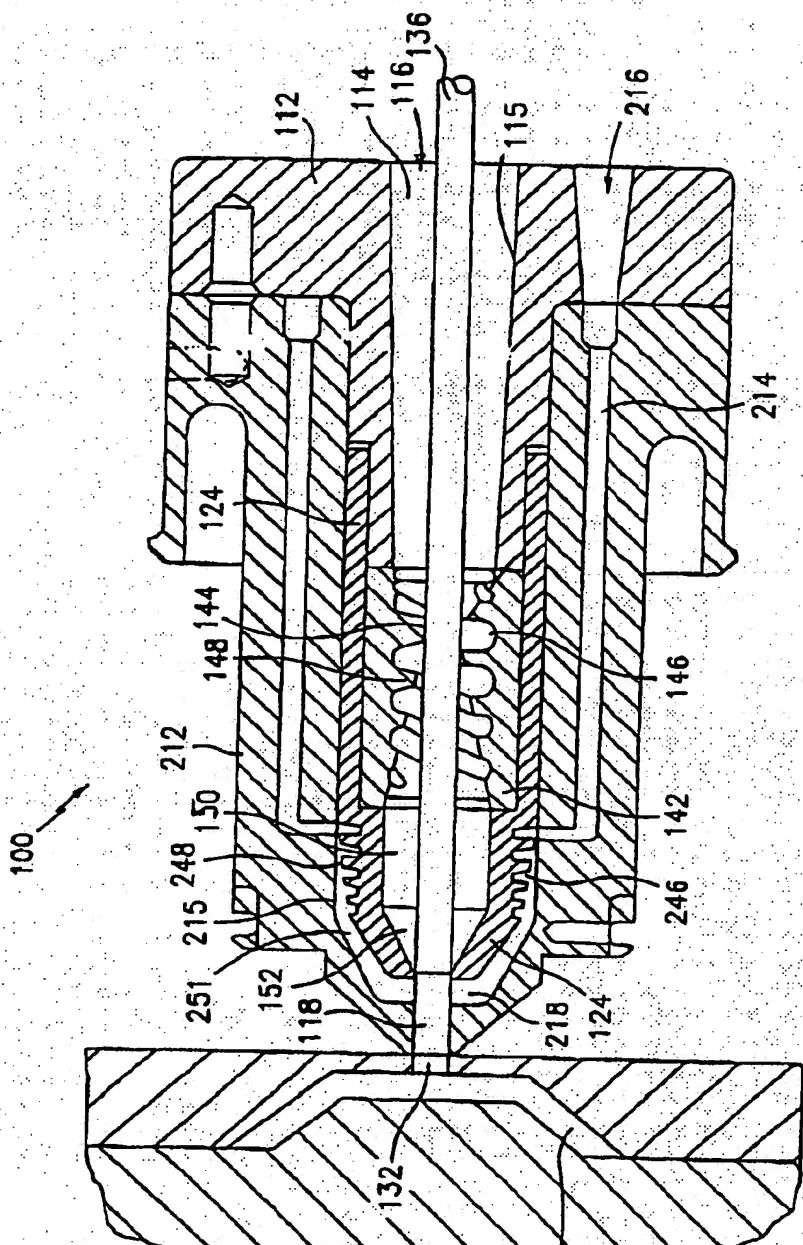

100
112
114
116
136
115
216
214
124
144
148
146
212
142
150
248
246
215
251
152
118
218
124
132
120

FIG. 10

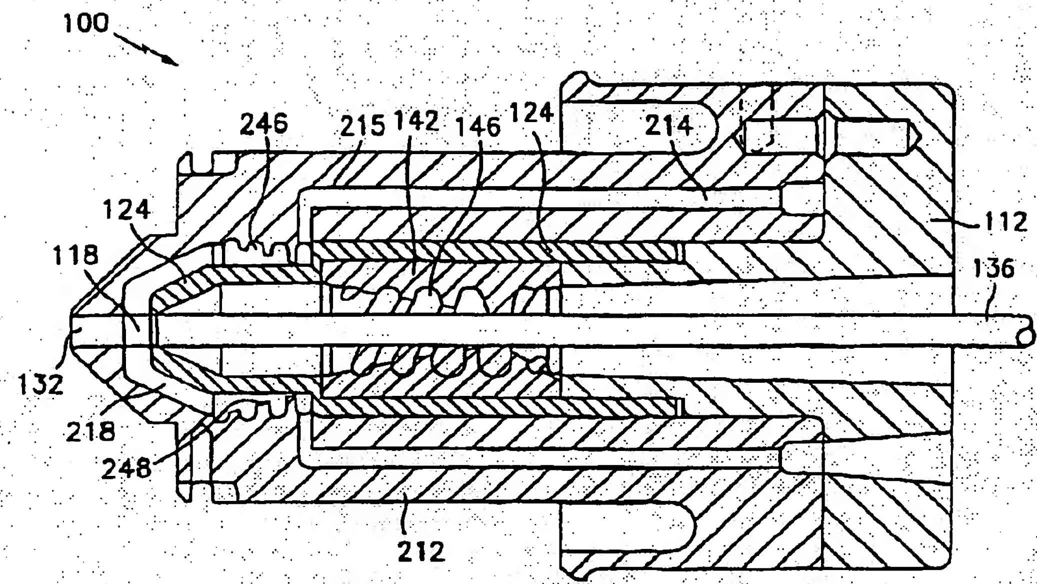


FIG. 11

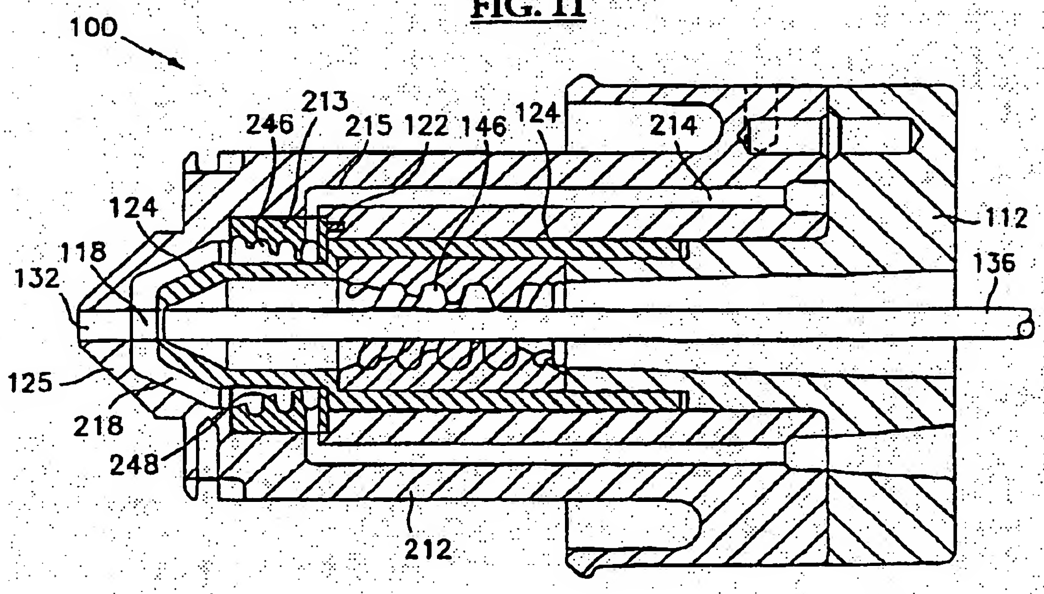


FIG. 11A

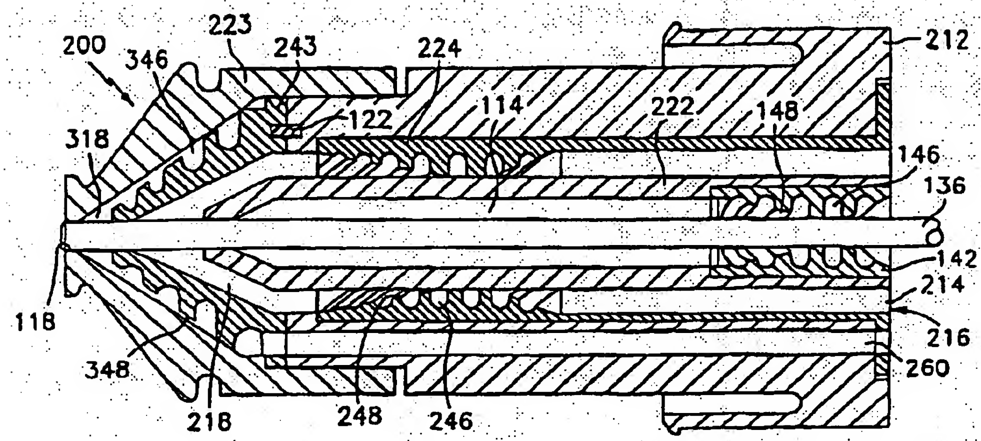


FIG. 12

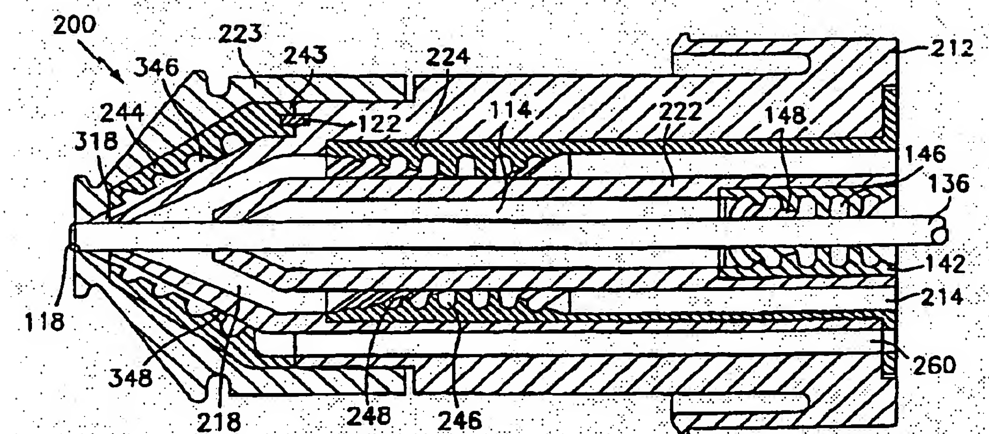


FIG. 12A

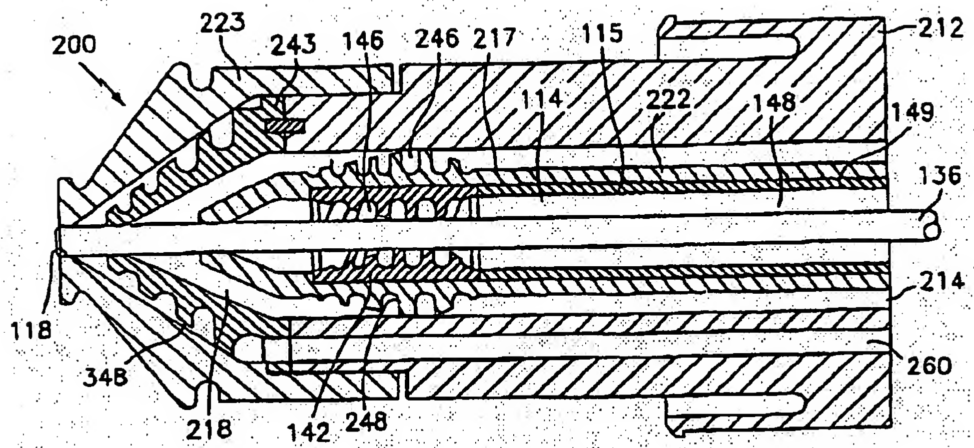
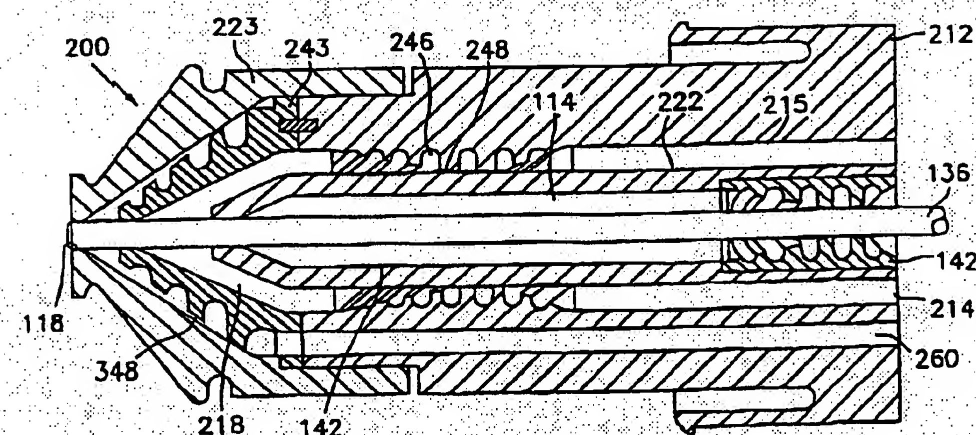

200
223
243
146
246
217
115
212
114
222
148
149
136
214
118
348
218
142
248
260

FIG. 13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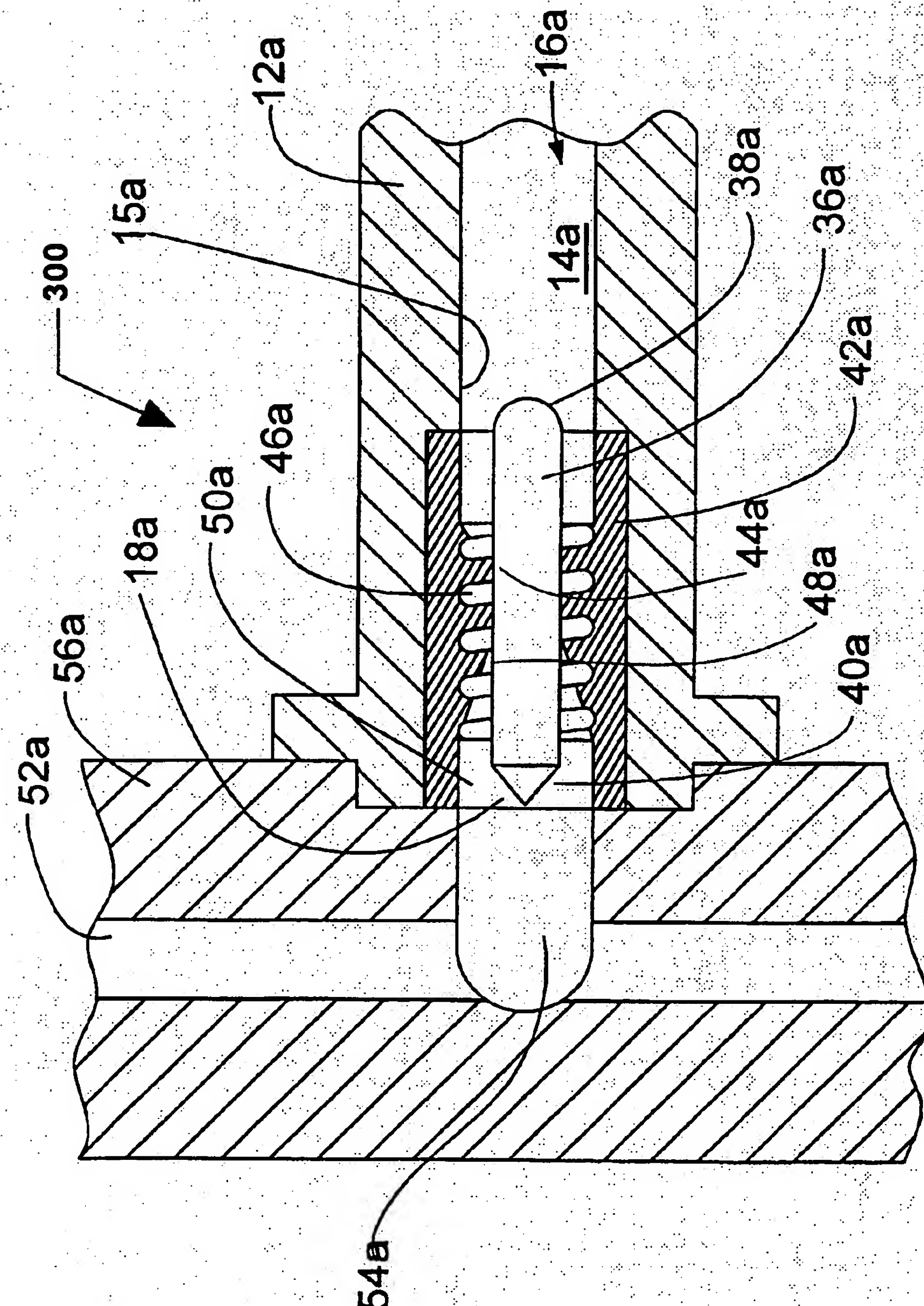
142
214
260
118
348
218
142

FIG. 14


300
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16a
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36a
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46a
50a
44a
18a
48a
56a
40a
52a
54a

FIG. 15

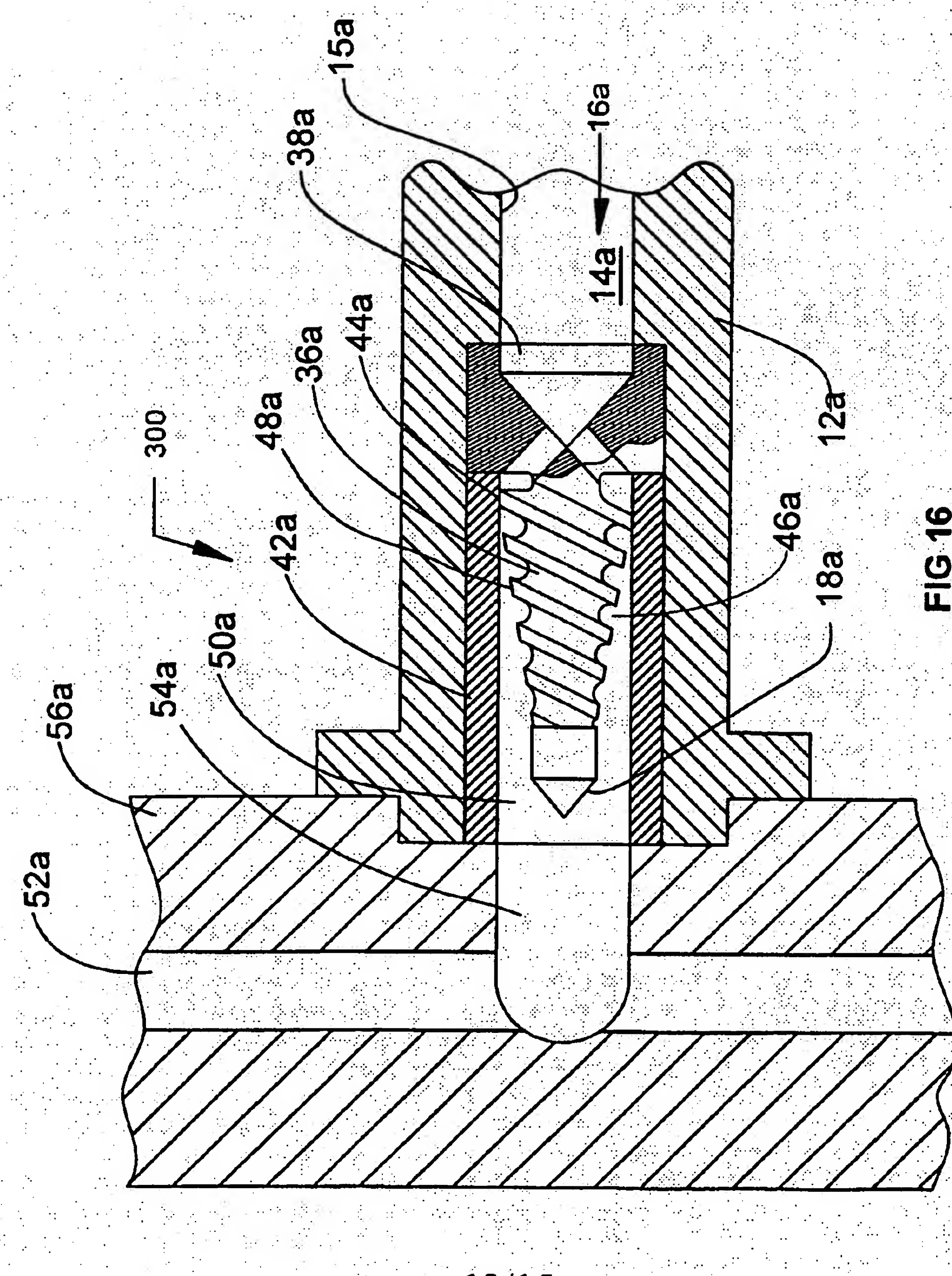
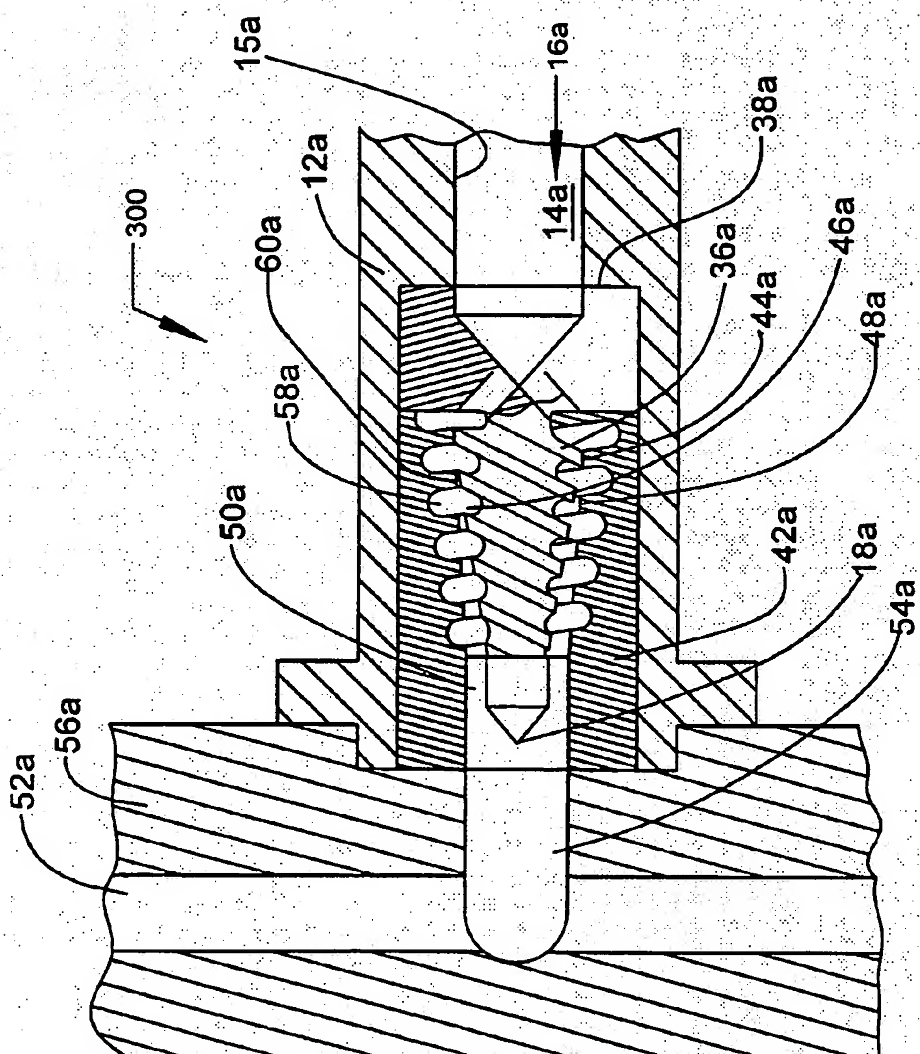


FIG 16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46a
48a
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50a
42a
18a
54a
56a
52a

FIG 17

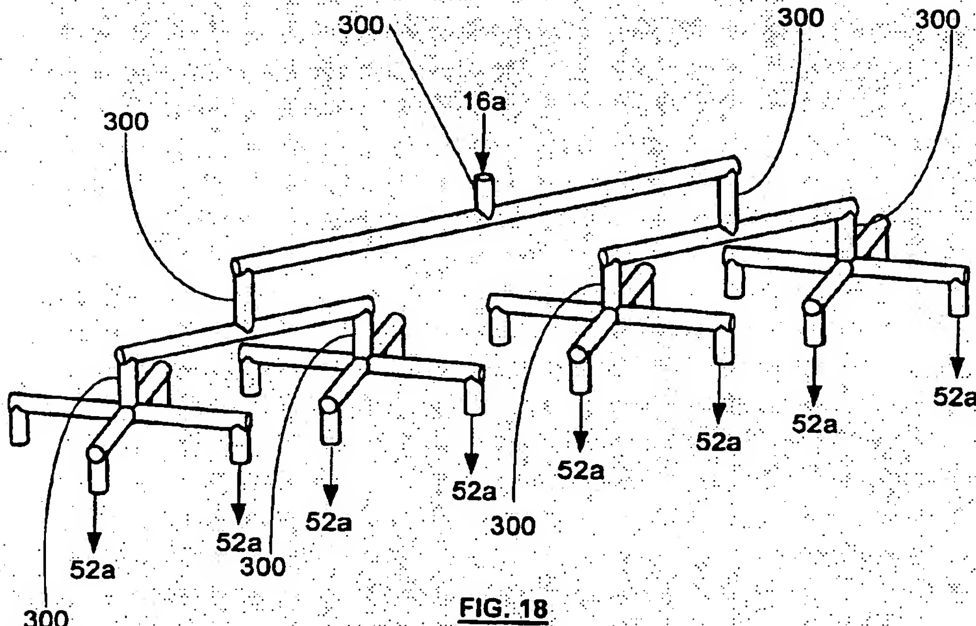

FIG. 18

INTERNATIONAL SEARCH REPORT

Intern nal Application No
PCT/CA 00/01092

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29C45/30 B29C45/28 B29C45/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 916 605 A (SWENSON PAUL ET AL) 29 June 1999 (1999-06-29)	1,3,6,8, 12, 19-21, 26,29
A	column 3, line 31 -column 5, line 15; figure 3	15,32
A	EP 0 825 008 A (HUSKY INJECTION MOLDING SYSTEMS) 25 February 1998 (1998-02-25) cited in the application column 6, line 36 -column 8, line 49; figures 1-3	1,3,7,8, 12,19, 20,26,29
A	EP 0 911 138 A (MOLD-MASTERS LTD) 28 April 1999 (1999-04-28) the whole document	36,42

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 January 2001	11/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bollen, J

INTERNATIONAL SEARCH REPORT

.ormation on patent family members

Interr ,al Application No
PCT/CA 00/01092

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			JP	10076551	A	24-03-1998
			US	5900200	A	04-05-1999
EP 0911138	A	28-04-1999	CA	2219260	A	23-04-1999
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			BR	9804470	A	23-11-1999
			CN	1215658	A	05-05-1999
			DE	19848817	A	29-04-1999
			JP	11198189	A	27-07-1999